Use of Uninhabited Aerial Vehicles to Improve Weather Forecasts Up to 14 Days

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Introduction: Relation to Strategic Focus Areas and National Priorities

This paper presents a suggestion for an initiative by NASA to develop a capability, jointly with the national and international communities, to provide certain key measurements of atmospheric state and other parameters for the purpose of improving weather forecasts. The immediate context for this effort is the international weather research program THORPEX, which is emphasizing the cooperation of the modeling and observing communities, the research and operational communities, the end user, and societal and economical impacts. THORPEX is a 10 year international research program that focuses on improving the prediction of short-range and medium-range high impact weather. THORPEX is a component program of the **WMO** World Weather Research Program (WWRP) and is the meteorological component of the International Polar Year. The Strategic Focus Areas addressed are the Exploration of the Dynamic Earth System, and the Advanced Aeronautical Technology areas.

Objectives

Operational synoptic surveillance missions using manned aircraft are acknowledged to have greatly advanced 1-3 day forecasts of the tropical cyclone's track and intensity. These targeted observations are presently selected subjectively and are limited by the capabilities of both the employed platforms and their crew. Targeted observations using unmanned aerial observing systems can be expected to further improve the short-range forecast of these high-impact events and to enable improvements in weather forecasts up to 14 days while mitigating the hazards and limitations of current observing systems. The long-term objective of this initiative is to develop and demonstrate the technology (model-driven adaptive targeting and unmanned aerial observing systems) to fill the measurement gap between satellite and earth-based observations.
The objectives for this effort are documented in the THORPEX International Plan as available at http://uswrp.org/thorpex. In general terms, they support the overall objective of improving the ability to forecast high-impact weather at a range of 1 day to 2 weeks. Although forecasting has greatly improved due to more and better observations, as well as more sophisticated models and faster computers, challenges remain in areas of high-impact weather such as hurricanes, wintertime storms, and severe convective weather. Recent examples include the Atlantic hurricane Frances in the most recent season, and the East Coast snowstorm of February, 2003. In such instances of difficult forecasts, different models often have different predictions, not agreeing on the storm path, intensity, etc., until valuable time passes during which more advance preparations could have been made. The THORPEX plan emphasizes *adaptive observations* as key to meeting the objective of improving these (currently) difficult forecasts. Adaptive observations are measurements of atmospheric state (e.g. wind and temperature) that augment routine operational data made at times and places determined by the numerical modeling systems.

Present Measurement Gaps

Currently routine, operational measurements include many sources such as rawinsondes, in situ ground stations, radar profilers, satellite data, precipitation radars, and measurements from ships, buoys, and commercial aircraft. Although the volume of data today is orders of magnitude greater than that of just a few decades ago, there are still regions of data voids, and rawinsondes are routinely released just twice daily. Satellites fill in much of the gap in clear areas over the oceans and under-represented land areas for temperature and water vapor, but profiles of the important atmospheric state variables, especially winds, remain elusive. Although TRMM provides radar and passive microwave information on storm structure, it does not provide atmospheric state observations, the latitude range is limited, and the timeliness can be lacking when addressing specific forecast challenges due to the non-geosynchronous orbit and limited number of observations.

Suggested Solution

The suggested approach of this paper is to develop unmanned aerial vehicles (UAVs) and the associated instruments needed to improve weather forecasts. This platform and measurement technology can be developed by NASA under the auspices of to two of its missions, namely understanding the dynamic Earth system and the development of aeronautic technology. As a first step in the process, commercially available aerosondes (small UAVs that measure in situ temperature, pressure, winds, and moisture) can be deployed to extend the range of these measurements into oceanic regions. Technology development can increase the range and volume of these measurements (for example, by improving efficiency of the engines). In addition, High Altitude Long Endurance UAVs can be directed to unstable atmospheric areas where they can drop sondes to improve atmospheric initial states. The development of measurement technologies to augment the satellite temperature and water vapor measurements would include UAV-based capabilities to map wind fields (e.g. Doppler wind lidar) and storm structure (e.g. polarimetric radar). Such (active) measurement capabilities could dramatically improve the reliability of the forecasts because dynamically active regions are usually characterized by winds that cannot be inferred from satellite or other measurements of temperature and pressure.

Potential Benefits

The benefits of improved weather forecasts are numerous, valuable, and extensively documented in the THORPEX plan and elsewhere. The development of a UAV capability will add unique capabilities to existing manned platforms, namely extended-duration flights, ability to take measurements in remote locations and in severe weather or life-threatening conditions, eliminating loss of pilot-life. An additional advantage (beyond the direct benefit of the measurements) for Doppler lidar and other examples is that it would provide technological development toward space-based capabilities.